Makoto NISHIDA* & Harufumi NISHIDA**: **Structure and affinities of the petrified plants from the Cretaceous of northern Japan and Saghalien. II. Petrified plants from the Upper Cretaceous of Hokkaido (2)*****

西田 誠*・西田治文**: 北日本及びサハリンの白亜紀産石化植物 II. 北海道上部白亜紀産石化植物 (2)

(Pl. XIII–XVII)

Among about ten species of taxodioid woods hitherto known in the Mesozoic flora of Japan, only three species of two genera have traumatic resin canals: *Taxodioxylon albertense* (Penhallow) Shimakura (1937) from the Upper Cretaceous of Fukushima Prefecture, *Oguraxylon yubariense* Nishida (1974) and *O. pseudoyubariense* Nishida et H. Nishida (1984) from the Upper Cretaceous of Hokkaido. The latter two are unique in having tertiary spiral thickenings on the tracheids. Following the preceding report on the description of three species of petrified plants from Hokkaido (Nishida & H. Nishida 1984), we have added here four species of *Taxodioxylon* with traumatic resin canals to the Cretaceous flora of Hokkaido.

Taxodioxylon albertense (Penhallow) Shimakura, Sci. Rep. Tohoku Imp. Univ. 2nd ser. **19**: 45 (1937). Nishida and Hara, Bull. Marine Lab., Chiba Univ. **10**: 4 (1978). *Sequoia albertensis* Penhallow, Ottawa Naturalist **12**: 83 (1908). Seward, Fossil plants vol. **4**: 347 (1919). Kräusel, Plaeontogr. **62**: 239 (1919). (Pl. XIII).

Materials. Specimens nos. 73240, 73543, 822951, 823451, 823452 and 823503 are fragments of the secondary wood, 5–10 cm × 2–5 cm × 5–15 cm, and fairly well

* Laboratory of Phylogenetic Botany, Faculty of Science, Chiba University. 1–33 Yayoicho, Chiba 260. 千葉大学 理学部生物学科.

** International Budo University. 841 Monomizuka, Shinkan, Katsuura, Chiba Prefecture 299–52. 国際武道大学 体育学部.

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preserved in histology.

Locality. Hifumi-zawa, a tributary of the Kamikinenbetsu River, Tappu, Obira Town (no. 822951); Kumaoi-zawa, a tributary of the Ikushumbetsu River, Ikushumbetsu, Mikasa City (nos. 73240, 73543); Omaki-zawa, a tributary of the Shuparo River (nos. 823451, 823452) and a tributary of the same system near south end of Sanyu Tunnel (no. 823503), Oyubari, Yubari City.

Horizon. Upper part of Middle Yezo Group, Turonian (Hifumizawa); Middle part of Upper Yezo Group, Coniacian (Kumaoi-zawa); Upper part of Upper Yezo Group, Santonian (Shuparo River).

Distribution. Canada, U.S.A. and Japan: Fukushima Prefecture (Upper Cretaceous, Coniacian-Santonian) and Chiba Prefecture (Lower Cretaceous, Barremian-Aptian). New to Hokkaido.

Brief note. Bordered pits on radial walls of tracheids usually arranged in one or two rows. Crassulae often visible. Rays uniseriate, often biseriate in part, usually 1-30, often up to 40 to 50, cells high. One to four, generally two or three, taxodioid pits in the cross field. Traumatic resin canals sometimes appear as tangential series.

These diagnostic characteristics coincide with those of *Taxodioxylon albertense* (Penhallow 1908, Shimakura 1937).

Taxodioxylon pseudoalbertense, sp. nov. (Pl. XIV; Fig. 1).

Material. Specimen no. 73504 (holotype) is fragment of the secondary wood, 5.0 cm × 3.5 cm × 6.0 cm, and fairly well preserved in histology.

Locality. Kumaoi-zawa, a tributary of the Ikushumbetsu River, Ikushumbetsu, Mikasa City (no. 73504).

Horizon. Middle part of Upper Yezo Group, Coniacian (Kumaoi-zawa).

Description. Wood consisting of tracheids, rays and wood parenchyma, and devoid of normal resin canals. Growth rings visible. Transition from early to late wood somewhat abrupt. Late wood several cells wide. Tracheids polygonal in outline in cross section, 26-54 μm in radial and 29-54 μm in tangential diameters, and pitted on both radial and tangential walls. Bordered pits on radial walls arranged in one or sometimes two rows separately or sometimes contiguously, and if in two rows, they are arranged oppositely. Pits 12-15 μm in diameter with pit aperture of 4-5 μm in diameter. Small pits, 10 μm in diameter, sparsely dispersed on tangential walls, especially in the late wood. Rays uniseriate or sometimes biseriate in part, 1-18, usually 1-7 (85%), cells high or

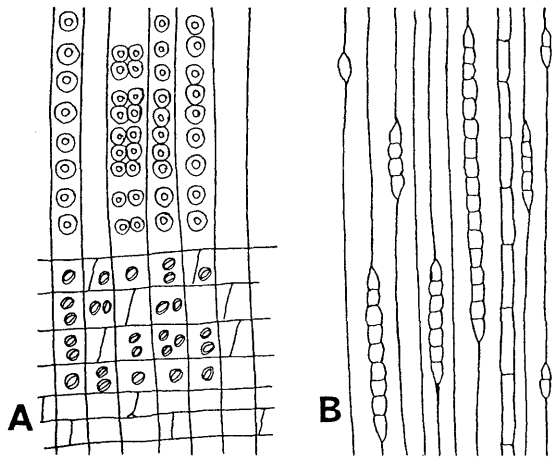

Fig. 1. *Taxodioxylon pseudoalbertense*, sp. nov. A: Radial section. B: Tangential section showing rays more than 10 cells high.

20 μm–300 μm in height, and arranged at intervals of 1–15, in average 5.2, rows of tracheids. There are 7–14, in average 9.5, rays per 1 mm. Ray cells vertically elongated elliptical, or barrel-shaped, 17–25 μm in vertical and 10–14 μm in horizontal widths in tangential section, and pitted on radial walls only. One or two, horizontally or vertically arranged, taxodioid pits in the cross field. Wood parenchyma abundant, scattered throughout the wood, often arranged in sparse tangential series. Traumatic resin canals often appear along outer periphery of the inclements, 80–120 μm in diameter and encircled by 8–11 epithelial cells and septate tracheids in that order.

Affinity. As described above, diagnostic features of the specimens in hand coincide with those of *Taxodioxylon albertense* except for the difference in height of rays. The specimens in hand have rays less than 20 cells high, while the latter has rays reaching 40–50 cells high. The specimens would be fragments of branches of *T. albertense* (see Discussions).

Taxodioxylon nihongii, sp. nov. (Pl. XV; XVII, A, B; Fig. 2).

Materials. Specimens nos. 73242 (holotype), 822952 and 823119-a are parts of twigs, 8 mm–20 mm in diameter and 2–4 cm long, with pith in the center, and well preserved in histology.

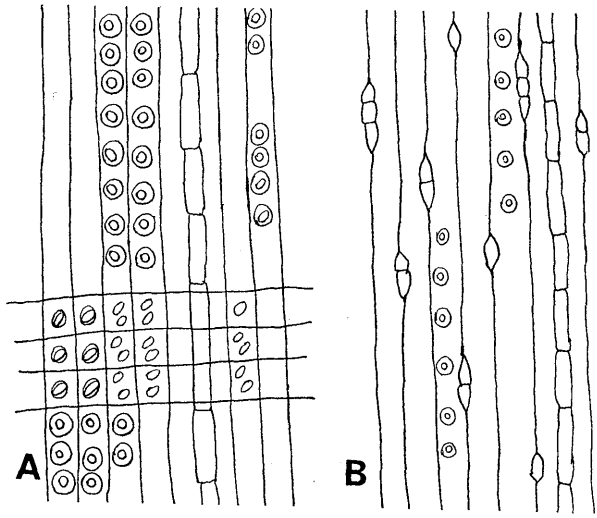

Fig. 2. *Taxodioxylon nihongii*, sp. nov. A: Radial section. B: Tangential section showing low rays less than 5 cells high.

Locality. Kumaoi-zawa, a tributary of the Ikushumbetsu River, Ikushumbetsu, Mikasa City (no. 73242); Hifumi-zawa, a tributary of the Kamikinenbetsu River (no. 823119-a) and Fujino-sawa, a tributary of the Nakakinenbetsu River (no. 822952), Tappu, Obira Town.

Horizon. Upper part of Middle Yezo Group, Turonian (Hifumizawa & Fujino-sawa); Middle part of Upper Yezo Group, Coniacian (Kumaoi-zawa).

Description. Wood consisting of tracheids, rays and wood parenchyma, and devoid of normal resin canals. Growth rings faintly visible. Transition from early to late wood abrupt. Late wood 1-2 cells wide. Tracheids polygonal in outline in cross section, 15-25 μm in radial and 12-30 μm in tangential widths, and pitted on both radial and tangential walls. Bordered pits on radial walls of tracheids arranged in a single row separately or sometimes contiguously. Pits circular, 10-12 μm in diameter with pit aperture of 4 μm in diameter. Small pits, 8 μm in diameter, dispersed on tangential walls. Rays parenchymatous, always uniseriate, less than 10, usually 1-5 (85%) cells high or 19-122 μm in height, and arranged at intervals of 2-15, in average 7.2, rows of tracheids. Ray cells vertically elongated elliptical, 10-25 μm in vertical and 9-12 μm in

horizontal widths in tangential section, and pitted on radial walls only. There is usually one or rarely two taxodioid pits in the cross field. Wood parenchyma abundant, scattered throughout the wood, often arranged in tangential series. Traumatic resin canals often appear along outer periphery of the inclement, 68–110 μm in diameter and encircled by 8–10 epithelial cells, and septate tracheids in that order. Primary xylem indistinct due to poor preservation. Pith consists of parenchyma cells and very large, suspicious mucilaginous cells, 80–110 μm in diameter.

Affinity. Presence of the traumatic resin canals is a characteristic feature of the specimens in hand. This and other characteristics of the specimens resemble the diagnostic characteristics of *Taxodioxylon albertense*, except for differences in height of rays, in number of rows of bordered pits on radial walls of tracheids (one in our specimens), and in number of half-bordered pits in the cross field (usually one in our specimens). *T. albertense* has rays usually exceeding 50 cells high, while our specimens have lower rays, less than 10 cells high. The former has one or two rows of bordered pits and 1–4 usually 2–3 pits in the cross field. The specimens in hand would be parts of twigs of *T. albertense* (see Discussions). *T. pseudoalbertense* Nishida et H. Nishida (in the previous chapter in this paper) also closely resembles the specimen in hand in general morphology, but differs from the latter in having higher rays reaching 20 cells high. Specific epithet is dedicated to Mr. Mitsutoshi Nihongi who has endevored to palaeontological survey in Hokkaido for a long time and assisted our field work there.

Taxodioxylon paranihongii, sp. nov. (Pl. XVI; XVII, C. D).

Materials. Specimens nos. 73522 (holotype), 73538, 822953, 823119-b, 823151, 823153, 823451 and 823516 are parts of twigs, 9 mm–20 mm in diameter, with pith preserved in the center, and fairly well preserved in histology.

Locality. Kumaoizawa, a tributary of the Ikushumbetsu River, Ikushumbetsu, Mikasa City (nos. 73522, 73538); Fujino-sawa, a tributary of the Nakakinenbetsu River (nos. 823151, 823153), and Hifumi-zawa, a tributary of the Kamikinenbetsu River (no. 822953), Tappu, Obira Town; Omaki-zawa, a tributary of the Shuparo River (no. 823451), and a tributary of the same system near south end of Sanyu Tunnel (no. 823516), Oyubari, Yubari City.

Horizon. Upper part of Middle Yezo Group, Turonian (Fujino-sawa and Hifumi-zawa); Middle part of Upper Yezo Group, Coniacian (Kumaoi-zawa):

Upper part of Upper Yezo Group, Santonian (Shuparo River).

Description. Wood consisting of tracheids, rays and wood parenchyma and devoid of normal resin canal. Growth rings faintly visible. Transition from early to late wood abrupt. Late wood composed of 2-3 layers of cells. Tracheids 15-25 μm in radial and 12-30 μm in tangential widths, and pitted on both radial and tangential walls. Bordered pits on radial walls of tracheids ordinary coniferous type, arranged in a single row contiguously or often separately. Pits circular, 12-15 μ in diameter with pit aperture of 6 μm in diameter. Tangential walls sparsely pitted by smaller pits, 10 μm in diameter. Rays parenchymatous, always uniseriate, 1-11, usually 1-5 (88%) cells high or 17-150 μm in height, and arranged at intervals of 1-15, in average 6.2, rows of tracheids. There are 8-12, in average 9.3, rays per 1 mm. Ray cells vertically elongated elliptical or barrel-shaped, 12-17 μm in vertical and 10-12 μm in horizontal widths in tangential section, and pitted on radial walls only. There are usually a single or rarely two taxodioid half-bordered pits in the cross field. Wood parenchyma scattered throughout the wood, abundant especially in the periphery of the inclement, and contains brown substances. Traumatic resin canals often occur along outer periphery of the inclement, 68-110 μm in diameter and encircled by 7-10 epithelial cells and septate tracheids external to the epithelial cells. Pith composed only of parenchyma cells, 30-70 μm in diameter, some of which are occluded with brown substances.

Affinity. The specimens in hand exhibit characteristics similar to those of *Taxodioxylon nihongii* Nishida et H. Nishida (the preceding species in this paper) except for the different structure of the pith. The present specimens have ordinary size of cells, 30-70 μm in diameter, in the pith, while *T. nihongii* has very large cells which are 80-110 μm in diameter and occluded with brown substances. This is the only one diagnostic feature to distinguish our specimens as a separate species from *T. nihongii*.

Discussion Four species reported above are very similar to each other in general structure; in having traumatic resin canals, 1-4 cross field pits, abundant wood parenchyma, 1-2 rows of separate or contiguous bordered pits on the tracheids. *T. nihongii* and *T. paranihongii* which are thin twigs consists of slenderer elements and of lower rays than those of *T. albertense* and *T. pseudoalbertense*. Nishida & Sudo (in preparation) examined anatomy of branches and twigs of *Sequoia sempervirens* Endl. which seems to have close affinity to *T.*

albertense in wood structure. They elucidated that the height of rays in 7-9-year-old trunk is usually 1-25 cells high and rarely attains 50 cells high which is nearly maximum height in *S. sempervirens*, while in 20-30-year-old branch the height of rays is 1-14, usually 1-8, cells high and in twig less than 10 years old 1-5 cells high. They also examined *Metasequoia glyptostroboides* Hu et Cheng and *Taxodium distichum* Rich. and recognized the same result in those species. Although their examination was based on only three species it can be generalized that in taxodioid wood the wood has lower rays in juvenile stage and higher rays in later stage. Rays in branch and twig are lower than those in trunk.

Of our specimens of *T. albertense*, no. 822951 has rays reaching 50 cells high, no. 73240 reaching 40 cells high, and no. 823451 reaching 31 cells high. Concerning *T. pseudoalbertense*, specimen no. 73504 has rays reaching 20 cells high which is close to no. 823451 of *T. albertense*. Whereas 85% of rays of *T. paranihongii* are usually 1-5 cells high, rays in no. 822953 reach 15 cells high and those in other specimens are less than 8 cells high. No. 822953 of *T. paranihongii* resembles closely no. 73504 of *T. pseudoalbertense* in the height of rays.

Bordered pits on radial walls of tracheids of *T. paranihongii* are arranged exclusively in a single row. While two rows of bordered pits occur in both *T. albertense* and *T. pseudoalbertense*. Such differences in the arragement of bordered pits are due to the width of the tracheids.

In the cross field *T. paranihongii* chiefly has a single taxodioid half-bordered pit, *T. pseudoalbertense* one or two pits, and *T. albertense* one to four pits. Number of pits in the cross field are also due to the widths of tracheids and ray cells. These facts were also examined by Nishida & Sudo (in preparation) in the twigs, branches and trunks of *Sequoia*, *Metasequoia* and *Taxodium*. Therefore it is highly probable that *T. paranihongii* is a twig and *T. pseudoalbertense* is a branch of *T. albertense*. *T. nihongii* also has possibility to be a twig of *T. albertense* in this respect. *T. nihongii*, however, differs apparenly from *T. paranihongii* in the structure of pith.

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Explanation of plates XIII—XVII

Pl. XIII. *Taxodioxilon albertense* (Penh.) Shimakura. A: Cross section showing traumatic resin canals. B: Tangential section showing high rays. C: Radial section. D: Radial section showing cross field. A: ×28, B-C: ×75, D: ×165.

Pl. XIV. *Taxodioxylon pseudoalbertense*, sp. nov. A & B: Cross section showing traumatic resin canals. C: Radial section. D: Tangential section. A: ×28, B: ×75, C-D: ×150.

Pl. XV. *Taxodioxylon nihongii*, sp. nov. A: Cross section showing traumatic resin canals. B: Cross section of pith with large cells occluded with brown substances and the primary xylem. C: Radial section showing cross fields with a single pit and bordered pits arranged in one row. D: Tangential section showing low rays. A-B: ×75, C-D: ×150.

Pl. XVI. *Taxodioxylon paranihongii*, sp. nov. A: Cross section showing traumatic resin canals. B: Cross section showing pith consisting of ordinary size of cells and the primary xylem. C: Radial section showing cross fields with two vertical pits and bordered pits arranged in a single row. D: Tangential section showing low rays. A-B: ×75, C: ×150, D: ×75.

Pl. XVII. *Taxodioxylon nihongii*, sp. nov. (A & B) and *T. paranihongii*, sp.

nov. (C & D). A & B: Radial sections showing pith with large cells. C & D: Radial sections showing pith consisting of ordinary size of cells. A: ×28, B-D: ×75.

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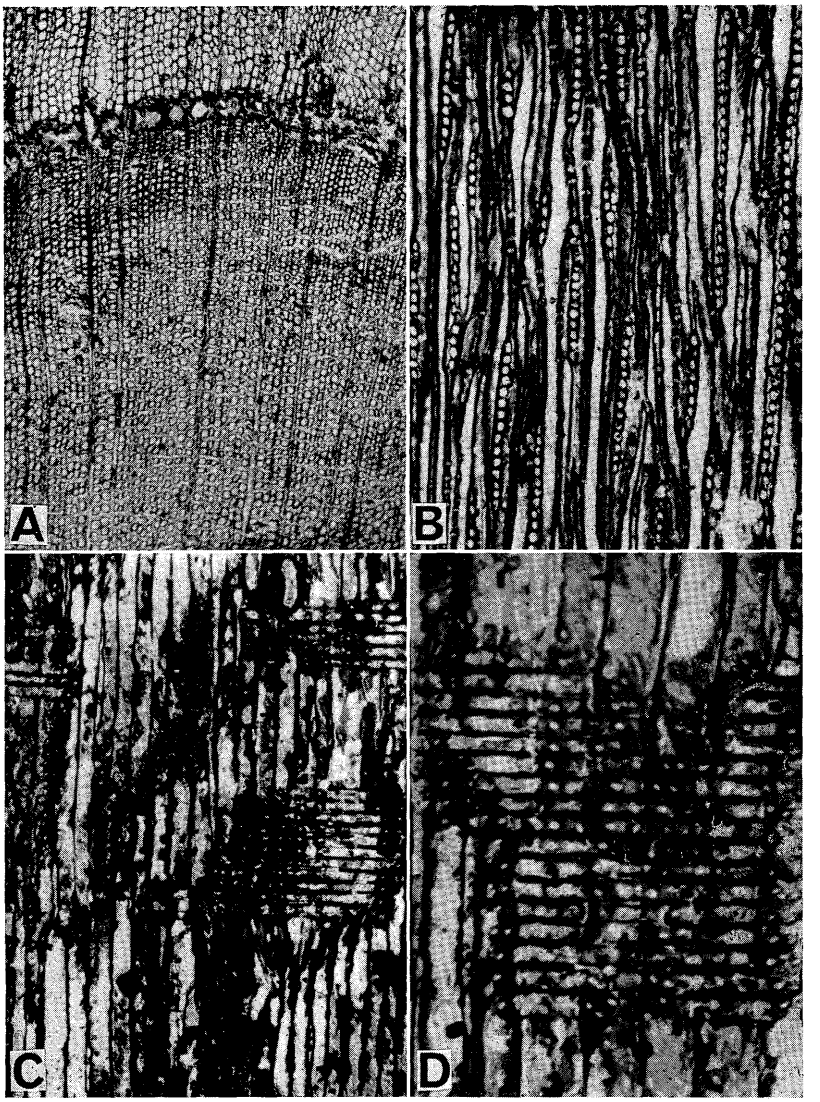
前報（西田・西田 1984）にひきつづいて，傷害樹脂道をもったスギ科の材 *Taxodioxylon* の4種，*T. albertense*, *T. pseudoalbertense*, *T. nihongii* および，*T. paranihongii* を報告する。後の3者は新種である。

北海道各地の上部白亜系からは傷害樹脂道をもったスギ科材が多数産出する。材の太さはさまざまで，小さいものは径 10 mm 以下のものもある。材構造は基本的には同型で，それぞれ樹幹（*T. albertense*），枝（*T. pseudoalbertense*），小枝（*T. nihongii*, *T. paranihongii*）という関係が推定される。西田・須藤（発表準備中）は *T. albertense* に近縁といわれている *Sequoia sempervirens* について樹幹，枝，小枝における放射組織の高さと樹齢との相関を調べ，上述のよう推定できると考えた。*T. albertense* の放射組織は50細胞高以上になり，*T. pseudoalbertense* では20細胞高止り，*T. nihongii* と *T. paranihongii* では主に1-5細胞高である。後2者は材構造が全く同じで区別できないが，髄中の巨大細胞（分泌細胞?）の有（*T. nihongii*），無（*T. paranihongii*）により，はっきり区別できる，*T. albertense* と *T. pseudoalbertense* は髄を欠くので，*T. nihongii*, *T. paranihongii* のどちらと同じであるかわからない。傷害樹脂道をもった北海道産の *Taxodioxylon* は形態上は4種，実質的には2種あると思う。

□横浜康継：**海の中の森の生態（海藻の世界をさぐる）** 247 pp. 1985. 講談社，東京. ¥640. 日本は食べられる海藻の生態や生理の研究は盛んで，世界の先導的役割を担っているが，食べられない，一見役に立ちそうもない海藻の研究となると，欧米に比べてお粗末である。横浜氏は私達海藻を研究する者にとって清涼剤とも言うべき本を著わしてくれた。「ワカメは何色」「ワカメからわかめへの変身」と言った，私達に身近な存在を導入として，内容は「補色適応説」「光合成の測定」「海中の森と草原の光合成と生産量」へと進み，続いて「海草藻場の物質循環」「アワビやウニの住む森」で生態系を論じ，「失われる万葉びとの海」「巨大海藻の危機」などで自然保護を話題にする。著者はいつしか私達を海の中の森に誘い，意外と知られていない海藻の生活の一断面を理解させる。永年，臨海実験所に勤務し，海藻の生理，生態の研究に従事してきた専門家だけに，内容は正確である。基礎知識が充分でない者にも読みこなせる。海中牧場や栽培漁業の基礎生産者として，あるいは潜在遺伝子資源植物として，近年，大方の注目を浴びるようになった海藻に，生きざまの面から迫る入門書である。　（千原光雄）



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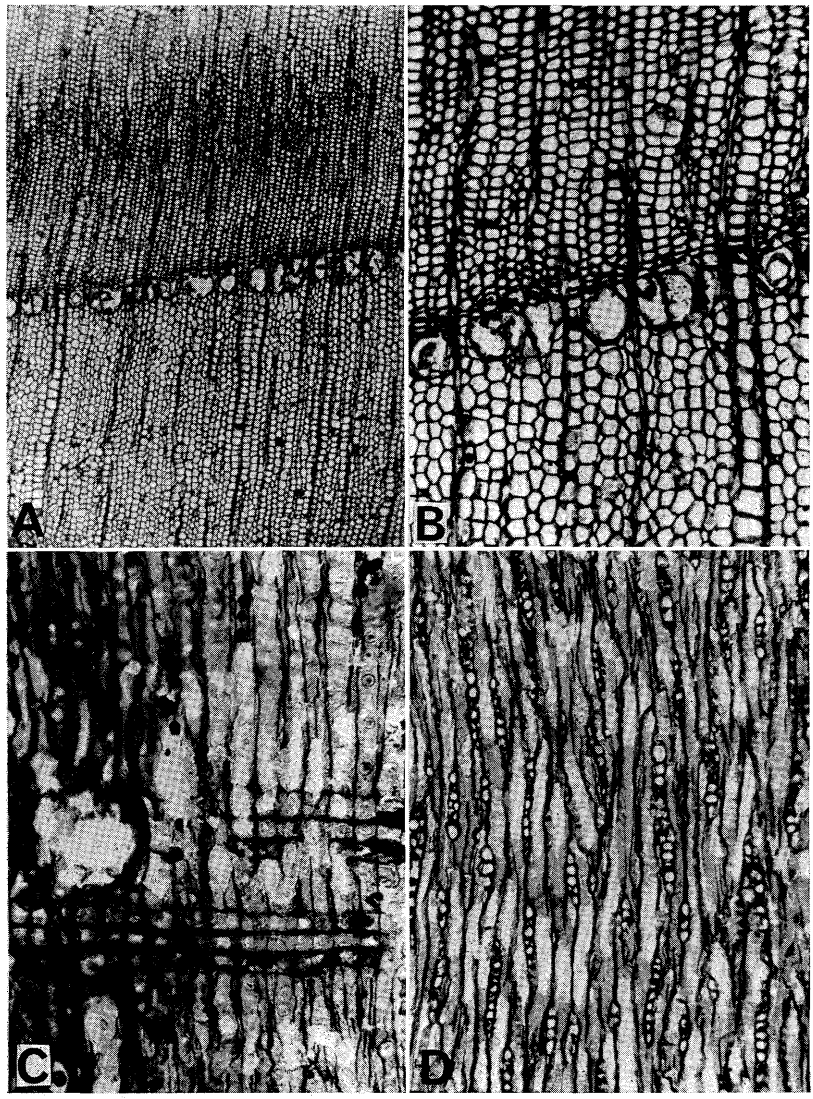

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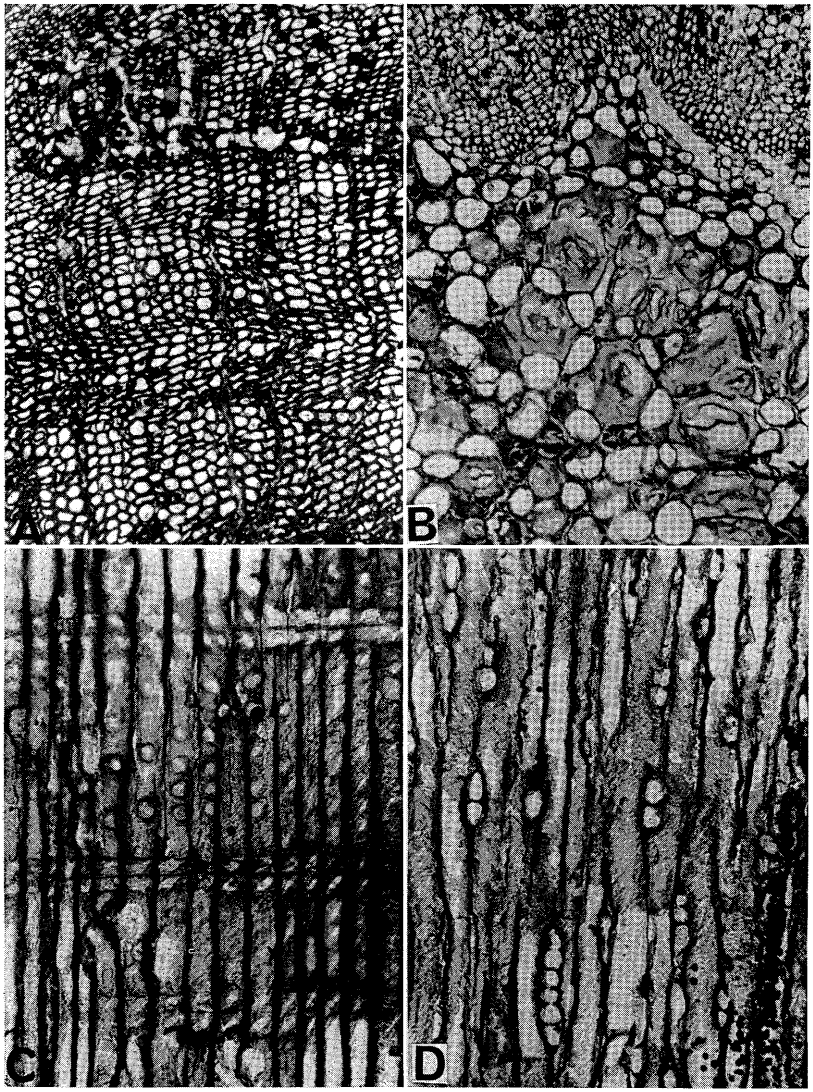

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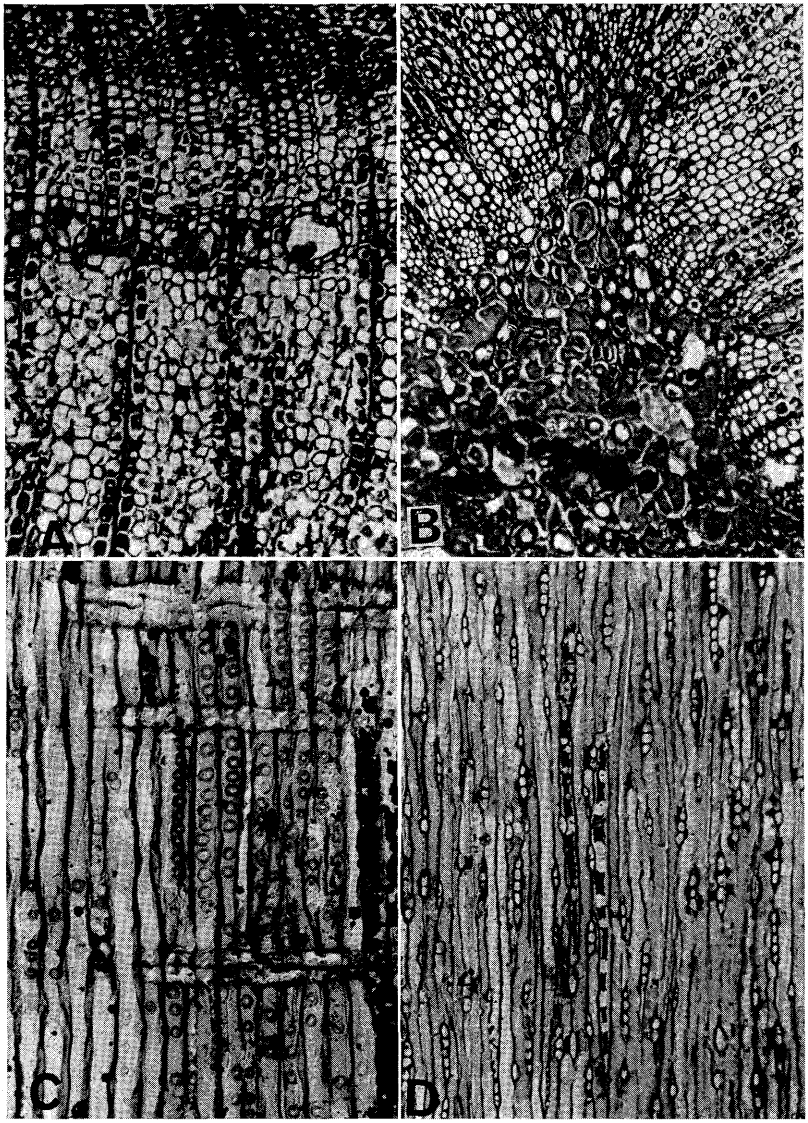

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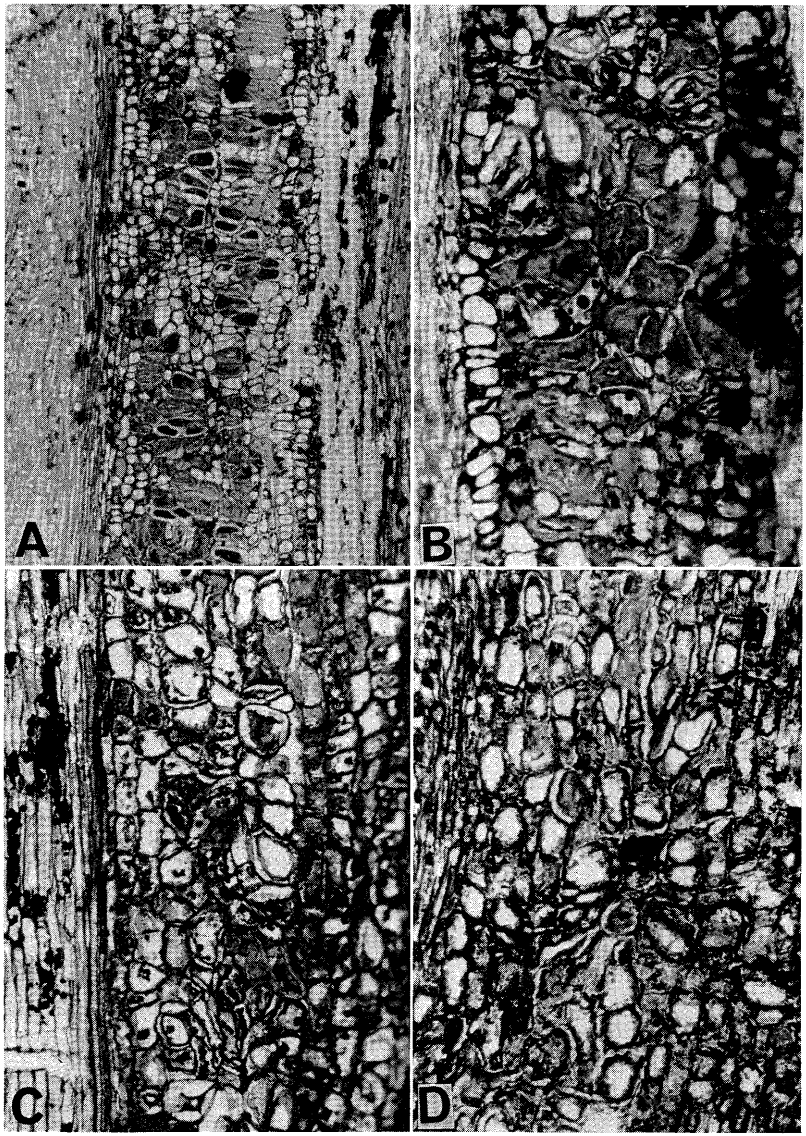

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